

SUSTAINABLE TRANSFORMATION ROAD MAP TO IMPROVED GLOBAL FOOD AND NUTRITION SECURITY: A NARRATIVE REVIEW

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Abstract

The current world population is exponentially expanding, which has been estimated to be more than 8 billion as recorded by the United Nations (UN). Food and Agriculture Organization (FAO) estimates that 870 million people in this global population cannot afford adequate food and the majority of the world (98%) lives in the developing world, where approximately 15% population of these countries face hunger. More precisely, the global population is projected to reach 9 billion in the year 2050, which would cause acute food shortages and strongly undermine international food security. It has also been found that food losses, particularly post-harvest losses because of inefficient agricultural methods, significantly affect the economy and the lives of the low and middle-income countries (LMICs). This means that pragmatic solutions must be set in place in regard to make sustainable agriculture systems, enhancing nutritional value and food security to eliminate hunger. This paper has explained the drivers of food insecurity, which are food losses, overpopulation growth, food hunger, food production and others. This report has also highlights some of the key transformative strategies that are value addition through proper food processing and preservation technologies, genetic engineering of the food crops, consumption of functional foods and incorporation of local nutrient dense underutilized food crops that have the potential to become transformative and comprehensive form of transformation that could be sustainable and holistic in food/nutrition security, particularly in underdeveloped nations, that are affected by the burden and prevalence of malnutrition, hunger and non-communicable diseases (NCDs) the most.

INTRODUCTION

The Food and Agriculture Organization of the United Nations (FAO) defines food security to be in a situation whereby all, irrespective of time or location, have access to sufficient, safe, and

nutritious food, both physically and monetarily, that could fulfil their dietary needs. Food security involves four interrelated features: availability, utilization, access, and stability. Nutrition security,

however, focuses on the utilization of food, especially on individual bodies and households' food diet (El Bilali, 2019). To enhance the existing global food-secured systems, it is of utmost importance to clarify the relationship that exists between food safety and security. Food safety involves commitment to guarded handling procedures and practices during food preparation, processing, storage and distribution with an aim of excluding food poisoning (FAO, 2020). Unsafe food is reported to contain parasites, viruses, harmful bacteria, and/or chemical compounds in most cases that can cause over 200 diseases across the globe, with diarrhea on one end and cancer on the other. The introduction and proliferation of foodborne diseases can be minimized significantly by good hygiene across the food and agricultural sectors. The quality of the diet is a vital interface between food and nutrition security. In the event of poor diet quality and health hazards, malnutrition, defined by insufficiencies in micronutrients and undernourishment, is likely to follow, as well as overweight and obesity, which also play a part in food insecurity (Godwin et al., 2022). The global COVID-19 pandemic of 2020 has brought about notable global food and nutrition insecurity threats. Its effects were experienced at all levels of society, although people in the low and medium-income areas were affected the most and showed the growing income disparities that already exist (Picchioni et al., 2022). Individuals experiencing moderate to severe food insecurity worldwide increased in 2020 to around 320 million, as compared to the past five years combined. This spike shows that food insecurity was considerably higher in 2020. At the same time, the number of households that could not afford healthy food was increasing both in Africa and Latin America in the period between 2017 and 2019, owing to unemployment, general job loss and shortened work hours, and it all led to paying low wages, food inflation, decreasing household earnings and population growth. The sophistry of zero-hunger by 2030 is brought out by the State of Food Security and Nutrition in the World (SOFI) 2021 report. A rise in global undernourishment (8.4% in 2019 to 9.9% in 2020) indicates an addition in victims: 46 million (Africa), 57 million (Asia), and 14 million (Caribbean and Latin America) (FAO, 2022).

According to the Global Burden of Disease Study of 2020, around 3.1 billion people (representing an augmentation of 112 million compared to 2019) were unable to afford a diet that could supply adequate health. This was the highest growth rate in Asia, where 78 million people were unable to cover the cost incurred by a healthy diet, followed by Africa (25 million), Latin America and the Caribbean (8 million), and Northern America and Europe (1 million). Food inflation, low purchasing power, and low self-declared income were marked out as the main triggers of the growing gap in this case (Murray, 2024).

Hunger, the Ever-growing Population, Food Pressure, and Food Supply

One of the central public health issues in the world is hunger. Among the key structural factors that support the case of hunger, particularly in the low and middle-income countries (LMICs), that have been consistently identified, are low income and poverty, poor governance, war, conflict, absence of freedom, poor status of women, and suboptimal health and nutrition interventions. This has highly impeded the food and nutrition security system of the growing nations. The existing systems are not adequate in curing and reducing the said challenges at a global scale, and in eradicating hunger. The Global Hunger Index (GHI) is an indicator that aims to provide an in-depth measurement and monitoring of hunger at the global, regional, and country levels. GHI employed the three indicators as: prevalence of undernourishment, childhood wasting and stunting and death among children in the measurement of hunger (Sabando et al., 2025).

Pronounced food insecurity continued to grow during the 2016-2021 period: the global prevalence swelled by 9.3% up to 11.7% in 2021, reflecting an extra 207 million people during the two-year period. The FAO indicators reflect these trends: in 2021, 828 million of the population were hungry, which is 46.3 million more people compared to 2020 and 150 million more compared to the year 2019. Among this world figure, Africa leads in the number of affected persons or percentage of the population (278 million individuals (3.2% of the population)) whereas Asia has the greater number of the undernourished persons (425 million, 9.1% of the

population) and Latin America and the Caribbean deploy 56.5 million people (8.6 percent of the population). Moreover, millions of Africans are also deprived of micronutrients, referred to as the hidden hunger (FAO, 2022).

The 2020 Global Nutrition Report indicates that about 22% of children aged below 5 years were stunted, 6.7% were wasted, and 5.7% were overweight worldwide. Both wasting and stunting were more prevalent among children growing up in poor households, rural background, particularly those whose mothers had no formal education. It was also revealed that children belonging to upper households with an urban setting were much more overweight (WHO, 2023). Demographic estimates point out that by the year 2030, the world population will have increased to 8.5 billion, 9.7 billion and 10.9 billion people by the year 2050 and 2100, respectively. (UN, 2022). The influence of population dynamics on the patterns of food availability and accessibility is strong as well, since the increase in population is likely to be translated into an increase in the worldwide food demand, thus increasing the level of food production. The initiative dealing with augmenting the availability of family planning services, particularly in the context of developing conditions, has been extended by incorporating strategic advocacy in addition to educational efforts. However, such measures should be reinforced and augmented, particularly by boosting the efforts at the national level. These would not only slow down a surging rate in the population but also enhance healthier lives and consequently strengthen the food security of households and the regions (Cliffer et al., 2025).

Food Production

Between 2000 and 2020, the world output of primary crops experienced marked growth of almost 52%, with data pertaining to commodity groups recording a production level of 9.3 billion tons in 2020. In this total, the staple crops as sugarcane, maize, wheat and rice, took about 50% of the total tonnage in number. At the same time, fruit production globally grew by 55% whereas vegetables experienced a 65% growth within the same period (Ritchie et al., 2022). The main type of crop produced within the 2020 harvest season was cereals

that comprised approximately one-third of the total production. Food growth output seen during the twentieth century can be viewed as the result of multiple parallel preconditions: better agricultural methods, enhanced reliance on irrigation systems, use of more pesticides, fertilizers and improved high-yield agriculture. The majority of primary crops can be sold without processing. However, certain crops need to be processed to come up with commodities that are used as fuel and food. They, hence, influence both nutrition and health, and energy and the environment (Oluwole et al., 2023).

The effect of food loss is highly negative on both the state and the public. Food is lost mostly during primary production and post-harvest levels, which amounts to about 60% of all food loss in regions with low incomes. Preventing wastage of cereal at the supply chain level can improve food security, reduce hunger, rural poverty in a sustainable manner, limit the amount of agricultural land needed to produce food and promote farmers' livelihood. Post-harvest loss is a physical decrease in quantity and an overall decline in quality that reduces the economic worth of a crop or makes it unacceptable to use as human food. In the worst situations, such losses can cost as much as 80 percent of the overall production (Ariyo et al., 2025). The losses are normally 20-40%, a high percentage, given that there is reduced farming output in most parts of Africa. And at the global level, estimates show that as high as a third of the food intended to be consumed by people is either spoiled or lost. The loss associated with food waste in industrialized nations is estimated at about US\$680 billion and US\$310 billion in developing nations (De & Das, 2025).

Value Addition: An Essential Food/Nutrition Security Tool

Value addition can be explained as the intentional addition of economic value into agricultural produce (such as wheat) by further processing of the produce by producing commodities such as flour to satisfy consumer preferences like bread, bakery, etc. Economically, one can consider value addition as a good investment decision since it helps in maximizing the productivity of a greater yield that enables expansion into a potential high-valued market and extends the production cycle, therefore

enabling creation of a brand name, and advancement of brand loyalty whenever the products or services are sold to consumers or customers (Haq et al., 2022).

The demand and consumption pattern of processed food has been drifting significantly in the last years due to existing pressures in society and the environment. At the same time, the swelling populations of the developing world, coupled with those of the low-income households devoid of nourishing foods, are crucial areas of concern to be approached in the elimination of hunger as well as mitigation of malnutrition, which are some of the agendas of a sustainable drive towards a global increase. Value addition, a critical technique to enhance diet diversity, may be accomplished by inexpensive methods of food processing with effective methods of preservation, resulting in significant food loss reduction in the world. Proper processing technologies ought to be designed to limit post-harvest losses and to develop sustainable value addition systems that would be supportive of better tackling of food insecurity, which can limit hunger, and generate employment. Access to proper infrastructures, especially proper transportation infrastructures enabling the use of raw materials as well as distribution of finished food productions to the consumers, has been found out to be a pivotal element of these initiatives (Kumar et al., 2025).

Global value addition through farming, including of fish, increased by 68% between 2000 and 2018, which was recorded at \$3.4 trillion in 2018. There is more than a doubling of value addition in the same period in Africa, where it moved up to USD 397 billion against USD 170 billion. The continent of Asia holds the number one position in the world in the size of different agricultural operations, with 63% of the global value contribution in forestry and fishing in 2018. Between 2000 and 2018, the region was able to boost its contribution to 77% with revenue rising to \$2,200 billion. There was a 47% increase in the case of America; 21% in the case of Oceania between the periods of 2000 and 2018. Value addition in agricultural production in Europe increased by 18 percent between 2000 and 2018, with the figure going up to USD 329 billion (Oluwole et al., 2023).

Contributions of the Food Industry in Food/Nutrient Security

The treatment of raw materials and the subsequent preserving operations make food items consumable and, at the same time, increase their storage stability. These types of operations expand the range of food commodities offered and make them more convenient for the needs of consumers in the short term. Moreover, processing of food resources attracts a lot of economic advantages through the creation of employment and income generation avenues and these trappings further contribute to expansion of consumer buying capacity, improvement of accessibility of foodstuff and universal availability of preferred nutrients (Knorr et al., 2020). Food processing industries involve activities that possess an overriding impact on the efficacy of current food supplies and can be described as a critical element of the current food/nutrition security, which depends on the availability of nutritious, safe, affordable and easily accessible food and food products to the entire population. It is thus due to the modern food-processing technologies that the difficult goal of providing a healthy diet to an expected global population of 9 billion by 2050 can be achieved. In addition, processing is a critical method of protecting the quality and nutritional content of food and increasing the general food shelf life. In this context, in the last few years, the food industry has explored several novel technologies as potential interventions, among them are high-pressure processing (HPP) technology, pulsed electric field (PEF) technology, cool plasma, ultraviolet irradiation, and ultrasound technology. In incorporating such non-thermal processes, the processors can lower the energy requirements implied in the conventional thermal operations and consequently boost the general energy effectiveness of the sector (Sharma et al., 2024).

The necessity of the promotion of resource efficiency is thus a top priority; the present-day agronomic practices are based on cheap energy sources, and are highly reliant on the availability of water and farmland, and are a key emitter of greenhouse gases throughout the world. As such, the food processing can underscore a comprehensive reduction of resource requirements within the entire spectrum of

primary production to the domestic consumer table (Panme et al., 2025).

The incorporation of technological training in the food sector has evidenced its potential to boost food production and distribution in the food sector through mechanized farming techniques and utilization of genetically modified foodstuffs. In addition, agricultural entrepreneurs should be specifically trained in basic production methods to strengthen food supply and consumption in agri-food systems. Therefore, the synergy among academicians, research centers and the food processing firm in the quest for disciplined development and research effort is one of the possible avenues to strengthening food and nutrition security sustainability (Rangavajla, 2025).

Biotechnological Innovations in Agriculture for Food and Nutritional Security

The current level of hunger that has been worsened by the economic disturbances caused by the COVID-19 concerns and an increase in global population requires researchers to come up with sound food systems that will protect food and nutrition security. Modern biotechnological practice provides breakthrough ways of achieving this goal. Such strategies are represented by genetically modified (GM) crops, which add a supplement to the current agri-food infrastructures, replacing native genes with their agronomic properties through gene sequence transduction (Gracia-Rodriguez et al., 2025).

According to FAO, a genetically modified organism (GMO) is defined as an organism that has been modified by the introduction of a gene or genes, commonly referred to as transgenes, into its genetic code using recombinant-deoxyribonucleic acid (r-DNA) technology (Olabinjo et al., 2020). GM foods consist of edible products that are products of organisms whose genomic entities, namely deoxyribonucleic acid (DNA), were altered intentionally or artificially, in that the changed genetic materials are not normally seen. This food is taking a trend in most of the developed countries and a number of developing nations. GM foods present a variety of benefits: (1) enhanced food supply both in the local and at the global level, (2) climate resistance and flexibility, which, in turn, would enhance the food supply at all levels and help

to offer it better food source, (3) higher nutritional value and safety, which, in turn, would have a positive impact on the economic access to food, and (4) others, such like improved shelf life, prevention of illnesses, allergies, malnutrition and food insecurity (Gasperini et al., 2021; Boluwade & Uche, 2021).

Unresolved Obstacles to Global Nutritional Equity

Public health and economic systems have often ignored their repercussions in the context of foodborne diseases that are felt in the low to medium-income countries. The group most at risk includes children under 5 years old, which makes up over 40% of all cases recorded; recent evaluations indicate that this population group also contributes to about 125,000 deaths per year. Also, an estimated productivity reduction of 95.2 billion US\$ is lost every year by LMICs, and the cost of treating diseases creates another 15 US\$ billion cost (estimated at 2019 World Bank). A secure food supply with the support of a high level of safety is essential to support economic growth, international trade and tourism, which, in turn, leads to the achievement of overall food and nutrition security goals (Keddy et al., 2025).

In the food industry, the state and individuals are both basic participants, and their mutual interaction is crucial in reducing world food insecurity. The population has the right to adequate food and nutritional satisfaction, thus maintaining the food-producing systems. Meanwhile, the private sector intensifies income security, provides the supply to productive agriculture, and supports the changes in the legislation that lead to the enhancement of human welfare. In its turn, the state elaborates a public policy, provides educational programs, and protects the right of people to food. Strong food security depends on the national and transnational strategic planning, which would help to generate employment, reduce human and natural disasters, promote sustainability, establish economic growth strategies, and increase accessibility of the population to the sources of nutrition (Gallegos, 2025).

Transforming Agri-Food Systems for Global Sustainability Nutrition

The key idea would be to make smallholder agriculture in the developing world productive and profitable to pull millions of people out of poverty permanently. This goal can be attained by maintaining a stable macroeconomic environment, good technology transfer, fair and safe property rights and jobs that go beyond agricultural production. The efficient systems of governance, especially at the national level, should provide the appropriate and updated information to be used on the past successful interventions, which have brought about similar changes (Nesamvuni et al., 2025).

Policies, legislation, and institutional interventions are the major public sector interventions that are relevant in the sustainable transformation. The war in Ukraine has affected the prices of wheat, maize, and vegetable oil, among other foodstuffs, leading to increased prices worldwide. Due to the Russo-Ukrainian War, there is also limited production of fertilizers, hence high costs of fertilizers in this region since they rely heavily on fertilizers, which they import. The Russian Federation and Ukraine produce and export minerals, fertilizers, energy and agricultural commodities that form the food basket of both countries, making 2% of the world Gross Domestic Product (GDP). Prior to the Russia-Ukraine war, Russia had been the biggest provider of fertilizers (in the form of Nitrogen, Potassium, and Phosphorus) in the world (ECLAC, 2022). This has caused a rise in food prices that is likely to negatively influence global food security, particularly in countries that are susceptible, such as in Europe, where countries have faced a negative impact due to the COVID-19 pandemic. Latin America and the Caribbean should therefore embrace agronomics by adopting good policies, producing fertilizer at cheap prices and supporting to achieve ways to mitigate insecurity in the region (Rabbi et al., 2023).

Integrating Functional Foods into Strategies for Nutrition Security

The concept of functional food can be described as a food product that has exclusive positive influences on some or all physiological functions that exceed the requirements of providing the required basic levels of nutritional value. The products will

contribute to improved health performance, lowered disease risk, and overall health. In line with this, increased consumer interest in such products has taken the functional foods to the center stage of modern food intake and consequently, the international marketplace (Yuan et al., 2024).

A large percentage of functional foods are of plant origin and have pharmacologically active components that incorporate flavonoids, catechins, carotenoids, lutein, lycopene and phenolics, etc. Evidence from empirical studies indicates they are present in millet, mushrooms, microalgae, flaxseed, oat, orange, soybean, onion, and cherry, and all have documented health benefits. Fruits and vegetables turn out to be other examples of abundant bioactive ingredients, such as carotenoids and polyphenols, substances that are considered beneficial. These products collectively have a wide range of health-promoting effects, which include, but are not limited to, cardio-protection, antioxidant activity, anti-inflammatory properties, anti-estrogenic capacities, antiviral action, anti-obesity functionality, hypoglycemic influence and anti-tumor potentials (Deshmukh et al., 2024).

Potential of Underutilized Crops for Enhanced Food/Nutrition Security

The role of underutilized crops as a means of improving food security is worth emphasizing. The majority of these crops have special adaptations that make them tolerant to unfavorable climatic situations, droughts, heterogeneous soils and still have high yield levels. Enset (*Ensete ventricosum*, *Musaceae*), an Ethiopian crop, is alike bananas both in the way it is grown and used. It is very prolific and often, the starch of it undergoes extraction, fermentation and is used as a food. Therefore, this less-exploited crop could be of great importance to overcome food and nutrition security challenges (Gebru et al., 2020).

Another Ethiopian grain of similar potential is teff (*Eragrostis tef*). Teff is a nutrient-rich food with high fiber, protein, minerals and polyphenols content and low gluten. It has been used in malting, brewing, production of non-gluten food and beverages (Saha et al., 2024).

Amaranth (*Amaranthus spp.*), more typically referred to as a pseudocereal, is naturally cream-colored and

sometimes pigmented (pink to brown), and it also survives in rough climates. It is a native, highly productive vegetable with an abundance of amino acids and minerals, especially lysine (Aderibigbe et al., 2022). It is evident that amaranth has anti-cancer health-promoting properties and has antihypertensive, anti-inflammatory and plasma cholesterol-lowering effects. The grain is predominantly high in nutrients and minerals, which makes it suitable for various uses that involve bread making, salad ingredients, porridge and infant complementary foods (Vorona et al., 2025).

Quinoa (*Chenopodium quinoa* Willd.), or golden grain as it is also referred to, is grown mostly in South America. This shows unusual drought, cold and salt-resistance, hence it can brave harsh and uncongenial climatic conditions. It is a protein-rich food having a better protein amino-acid profile compared. Its 2-9.5 percent fat level is higher than other grains, with the sole exception of soybeans; in addition, it contains comparatively high levels of minerals (Hassan & Ganai, 2025).

The Contribution of Food Regulatory Authorities to Ensuring Food and Nutrition Security

Various functions are undertaken by food and regulatory authorities to ensure that the food is secure. Various legislative tools, directives, and regulations have been issued to ensure that foods are safeguarded and wholesome, from farm to table. Such tools reflect that general protocols are always embraced and followed during the production, processing, distribution, transportation, and handling of the food items. Food authorities have jurisdiction differences in structure. The international forums are major organizations that design the drafts of globally acceptable regulations and standards that enhance national systems of quality control and safety in food products (Jha & Singh, 2025). There is a close consideration that should be given to nutrition education, especially in the participation of households in organic home production of vegetables. Agencies should also promote the growth of quality seeds to produce better crops. Another intervention that licensing agencies should consider is the encouragement of bulk production of underutilized crops, as well as

facilitating the trade and exportation of the same (Flores et al., 2025).

Conclusion

The most recent global food security report provides a comprehensive overview of food security issues today, thus stating the necessity of all food and nutrition players, including policymakers, regulators, and all food-related chain members, to target zero hunger in parallel with the advancement of healthy lifestyles. Specifically, there is a dire need to establish effective food safety initiatives capable of reducing the prevalence of foodborne pathogens by ensuring that the food processing activities are tightly monitored. At the same time, some crops and functional foods that are not being exploited fully need to be explored in terms of their nutritional value and ability to diversify diets in the world, so as to improve the status of diets and the acceptability of nutritious food products at large. Lastly, increased media coverage on the alteration of GMOs is part and parcel in creating awareness among consumers and enhancing societal acceptance, whereas coordinated regulation and safety-analysis activities by governments will further strengthen the context of generating viable road maps to achieve food security, particularly in the underdeveloped nations.

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